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Kia ora for inviting responses to the policy question *"How can innovation in the way we use information and emerging technologies help biodiversity thrive?"*[1]

The challenge is to identify solutions to problems, not just participate in a process that shifts harm and defers solutions.

Our response is provided in the spirit of wanting to help to restore and sustain "the mauri (life force) of nature." Innovation is clearly needed to achieve this objective, but so is learning from past mistakes. The problems caused by many exotic plants and animals in Aotearoa-New Zealand are themselves the outcomes of past innovations. For example, stoats were introduced as a biocontrol of rabbits[2] that were introduced for food, sport and fur.[3] These innovations were not called biotechnology, but were consistent with how we define it today because they were attempts to modify ecosystems to suit particular agricultural uses or to mitigate the impacts of those modifications.[4]

Both information and biotechnology can be powerful tools when applied to understanding the causes of harm to biodiversity, monitoring and identifying the source of harm, and informing strategic approaches to limiting or eliminating adverse effects on native organisms. When used in a precisely defined framework that emphasises *the value of biotechnology as an information provider, rather than a way to intervene in nature*, it can be used safely with little risk that future generations will be correcting mistakes, as we are correcting the mistakes of generations that preceded us.

Specific responses

- *Do you agree that we should focus on information and biotechnology to find ways to care for Aotearoa New Zealand's biodiversity in the future? Why or why not?*

The question itself suggests a trade-off but does not indicate how a focus on information and biotechnology would distract from other options, or why it would need to. A full answer to the question would require knowing what change this proposed new focus would cause.

We believe that the focus always should be on biodiversity rather than particular technological tools to address threats to biodiversity. To the extent that a focus on such tools is necessary, it should follow from a careful description of the problem to be solved and then

[1] https://www.doc.govt.nz/contentassets/4a6414ec062949aaaaa998ae59163d04/high-level-summary.pdf
[2] Cuthbert, R., and Davis, L.S. The impact of predation by introduced stoats on Hutton's shearwaters, New Zealand, *Biological Conservation* **108,** 79-92 (2002).
[3] https://teara.govt.nz/en/rabbits/print
[4] "'Biotechnology' means any technological application that uses biological systems, living organisms, or derivatives thereof, to make or modify products or processes for specific use." Convention on Biological Diversity https://www.cbd.int/doc/legal/cbd-en.pdf.

the elimination of other viable pathways to solution, with an emphasis on solutions that are both sustainable and address the root causes of the problem.

Information and biotechnology could support some harm mitigation pathways but likely also will have unintended consequences. Information is embedded in all human interventions into nature, but not all information is of the quality needed to achieve desired outcomes of sustained benefit to biodiversity. Biotechnology, which allows the harvest and analysis of eDNA for example, can support a focus on conservation. Using eDNA to design guide RNAs for genome editors, however, can result in tools that undermine conservation efforts.

Biotechnology applied to the manipulation of mauri is a different question, and a different focus. Of the kinds of biotechnology listed in the High Level Summary of the briefing consultation document, the use of gene editing, particularly as applied to gene drives or *in situ* genetic engineering using genome editors with or without gene silencing tools[5], take on the characteristics of scalability that are attractive but which also are the source of greatest potential harm.[6] Scalability derives from automation, mechanisation or deregulation of these tools.[6] This was also a feature of earlier technologies that have failed. Stoats were a scalable biotechnology for the control of rabbits because of their deterministic amplification without reliance on people to propagate in the environment.

- *Are there any parts of information or biotechnology that you think need to be covered in our Long-term Insights Briefing? This can include applications in other sectors and disciplines, international approaches, social innovation, and any unintended consequences.*

Aotearoa has an immature regulatory system for the oversight of biotechnology when it is used as a tool of intervention in Aotearoa mauri. As the recall and revision of the 2018 Environmental Protection Authority decision on the outdoor use of gene silencing tools illustrated,[7] there is a fundamental need for an increase in regulatory capacity and a decrease in the effort required for external informed views to participate in regulatory decision-making. *A change in focus from tools such as information and biotechnology to improved governance and cooperation between agencies and non-state actors, would be welcome.*

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[5] For more on this emerging biotechnology, see Heinemann, J. A. & Walker, S. Environmentally applied nucleic acids and proteins for purposes of engineering changes to genes and other genetic material. *Biosafety and Health* **1**, 113-123 (2019) https://www.sciencedirect.com/science/article/pii/S2590053619300266 and Heinemann, J. A. Should dsRNA treatments applied in outdoor environments be regulated? *Environment International* **132**, 104856 (2019) https://www.sciencedirect.com/science/article/pii/S0160412019306038.

[6] Heinemann, J. A., Paull, D. J., Walker, S. & Kurenbach, B. Differentiated impacts of human interventions on nature: Scaling the conversation on regulation of gene technologies. *Elementa Science of the Anthropocene* **9**, doi:10.1525/elementa.2021.00086 (2021). https://online.ucpress.edu/elementa/article/9/1/00086/116462/Differentiated-impacts-of-human-interventions-on?searchresult=1. Deregulation coupled with availability of kits, synthesised fragments of DNA or just nucleases changes scale by increasing number of users.

[7] "DOC considered that the submission documents brought the original determination decision into 'very serious doubt'. It also stated that it considered the laboratory use of dsRNA to be of low risk, but field use could be cause for concern. It therefore supported a reconsideration of the original decision, potentially with members of the Decision-Making Committee being drawn from outside the EPA HSNO Committee." https://www.epa.govt.nz/assets/FileAPI/hsno-ar/APP203395/APP203395_Decision.-Reconsidered-and-Reissued-June-2021.pdf

The responsible use of any biotechnology involves a holistic appraisal of its ability to scale and an ability to anticipate how harm is caused at application scale. The dimensions of harm can be on biodiversity and human health, but also on socio-economic systems. Likewise, various social systems, not just ecosystems, can be modalities that amplify harm.

In answer to the question, an unambiguous social licence should be secured before particular uses of information and biotechnology commence, and periodically renewed after any activity has been in use. The social licence should depend upon governance through legislation, with operational constraints adjusted according to how harm scales with use of information or particular tools and applications of biotechnology. In other words, the objective should not be to seek *a priori* approvals for unsupervised uses based on arbitrary (and often contested) definitions of genetic modification/engineering, genes and heritability, among other things, as has been suggested in some "tiered" regulatory frameworks.

- *How can we make sure we include other forms of expertise when making decisions about the use of information and biotechnology? Such as mātauranga Māori, social science and citizen science?*

There are two questions here. One is, who should be encouraged to participate? The other is how do we get them to participate?

In answer to the first question, additional publics for inclusion are the biotechnology technical experts that also have little voice in a technology-driven science sector that is predominantly using science research and technology development for short-term or eventual commercial outcomes.

In answer to the second question, there must be an environment in which it is safe to participate, the specific impediments to some publics is addressed (i.e. equity to empower, not just invitation to participate) and the outcome of the consultation must genuinely affect decisions, so that participants are not left feeling exploited by participating.[8]

(As a note, this consultation process appears to be failing to reach many publics that have an interest.)

- *What else should we consider?*

Presumably this consultation is a way to seek social license. In the process, avoid participating in the "hype cycle" built on hopeful imaginaries about what information and biotechnology will do, made well before any real demonstration of efficacy is available. "[D]o not over-promise and under-deliver."[9] Similarly, framing the consultation as a choice

[8] For extended list, see Montenegro de Wit, M. Democratizing CRISPR? Stories, practices, and politics of science and governance on the agricultural gene editing frontier. *Elementa Science for the Anthropocene* **8**, 9, doi:https://doi.org/10.1525/elementa.405 (2020). https://online.ucpress.edu/elementa/article/doi/10.1525/elementa.405/112758/Democratizing-CRISPR-Stories-practices-and?searchresult=1

[9] "The race to report novel CRISPR–Cas-based applications, as well as other biotechnologies, should not divert the scientific community from the necessity to provide sound and robust assessment of a technology's limitations…This hype can lead to the premature integration of relatively unproven technologies in research programmes, followed by more gradual reassessment of their limitations and failures. Some may view such an imperfect process (sometimes referred to as the 'hype cycle') as an unavoidable consequence of the modern

between benefits of using information and biotechnology and problems faced by not using it, without carefully examining how benefits are distributed to different publics and without careful disclosure of uncertainty, unnecessarily complicates the task for technical experts who can help to inform responsible use.[9]

We recommend that the process could be simplified and improved by grouping information and biotechnology of similar characteristics into categories for more targeted discussions.[10]

The first category is composed of tools that are applied to description and monitoring but which do not become part of Aotearoa's ecosystem. While these also can create anticipated and unintended harm, the scalable dimensions resulting in harm usually can be controlled by biological containment and regulation.[6] Tools in this category should be given priority in the process of applying for social license.

The second category includes information and biotechnology that is used to make changes in organisms or processes (how something is made) but not ecosystems. Some of these might rely on information and biotechnology in the first category. Information and biotechnology in this category are limited to uses for which the changed organism or process is fully contained. Most genetic technologies already have general social license and regulatory license for this kind of use in Aotearoa. Information may not.[11] The social dimensions of intellectual property, indigenous rights and international access and benefit sharing obligations are critical incubators of harm needing addressing.

The third category includes information and biotechnology that are used to make changes in organisms or products which may be released into ecosystems. There exists already limited social license for biotechnology in this category. The license has been used for "contained field trials" but is still untested for full release of living genetically modified organisms. Pre-release biological safety assessments and socio-economic evaluations can be used at the critical point prior to release, to reduce the likelihood or impact of unintended effects on biodiversity. However, the social license for the use of information and biotechnology in this category is probably due for renewal.

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innovation pipeline. However, we argue that it leads to wasted resources and places an unequal scientific and financial burden on under-resourced researchers, particularly in low-income and middle-income countries, to perform validation and implementation trials of hyped proof-of-concept studies." Mehta, D. and Vanderschuren, H. Towards responsible communication of agricultural biotechnology research for the common good. *Nature Reviews Molecular and Cell Biology* **22,** 301–302 (2021). https://doi.org/10.1038/s41580-021-00343-z. See also Schnurr, M.A. and Dowd-Uribe, B. Anticipating farmer outcomes of three genetically modified staple crops in sub-Saharan Africa: Insights from farming systems research. *Journal of Rural Studies* (in press) https://www.sciencedirect.com/science/article/abs/pii/S0743016721002266 for discussion of technology centred over-promise in farming systems.

[10] The characteristics here are those where the tools share scalable harm dimensions and thus respond to similar risk mitigation strategies. Another way of thinking about this is that the categories are sets of information and biotechnologies that have the same critical control points. See footnote 6. Note that *this is not* a call for tiered regulation wherein some information and biotechnology is deregulated based on description of process or tools. The categories customise the approach to risk assessment and risk management.

[11] Heinemann, J. A., Coray, D. S. & Thaler, D. S. Exploratory fact-finding scoping study on "Digital Sequence Information" on genetic resources for food and agriculture. Background Study Paper NO. 68. (United Nations Food and Agriculture Organisation, 2018). https://www.fao.org/3/CA2359EN/ca2359en.pdf.

The final category is composed of information and biotechnology both that is used to make changes in organisms that are then released, or used to make changes in organisms in the environment in real time.[5] Examples are the use of nucleic acids such as double-stranded RNA, or RNA and genome editing enzymes, formulated as topical, inhalation or ingestion mutagens or gene expression modulating agents, and gene-drives. The cumulative off-target effects on both target and non-target organisms from such technology is impossible to estimate on current and foreseeable knowledge. The risks arising from mechanisation or self-determination only has scale parallels in infectious disease. No social license exists for examples in this category although some regulatory license does for topical gene silencing agents.

Nāku iti nei, nā,

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[12] This submission and any accompanying documents are provided in accordance with the University of Canterbury Critic and Conscience of Society and Academic Freedom Policy (2018) as the author's expert opinion and not as statements of the opinion of the University of Canterbury.